BALLISTIC RESEARCH LABORATORY

REPORT

FIRING SIDEWISE FROM AN AIRPLANE

II.   EFFECTS OF A 400 MILE PER HOUR AIR SPEED

Project RX 114

by

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Abstract

The variations in the magnitude and orientation of the yaw in
the bore of a machine gun, firing sidewise from an airplane with a
speed of 400 miles per hour, might cause large dispersions at a range
of 500 yards; but not at 100 yards.

1.   OBJECT: In Part I, "Theoretical considerations",*
the motion of bullets fired from a machine gun, mounted
on an airplane with a speed of 200 mi/hr, in a direction
perpendicular to the line of flight of the airplane, was
studied; it was found that the maximum dispersion caused
by variations in the magnitude and orientation of the yaw
in the bore appears to be too small to ruin the accuracy
of fire. Since airplane speeds may be increased to 400 mi/hr
in the near future, the Chief of Air Corps has asked for
a determination of the effect of a cross wind of this
magnitude on the dispersion of machine gun fire.

* Ballistic Research Laboratory Report No. 116.

2.   DATA: Except for the air speed (600 ft/sec),
we shall assume the same conditions as before:

   a.   Bullet, Cal. 0.30 ball M1.
   b.   Direction of fire, horizontally to starboard.
   c.   Muzzle velocity, 2600 ft/sec.
   d.   Yaw in the bore, 0.15° (this is probably the
         largest yaw that would be obtained in a good gun).
   e.   Orientation of the yaw in the bore, at the muzzle,
         90° and 270° (these values give extreme conditions,
         as the variation is usually much less than this).

3.   YAW:

   a.   Under these conditions, the windage yaw is 12.995°.
This would be the initial yaw relative to the air if there
were no yaw in the bore.
   b.   With the assumed yaw in the bore, at an orientation
of 90°, the motion is somewhat different with a 600 ft/sec
cross wind than with a 300 ft/sec cross wind. In the latter
case, the initial yaw is a maximum, as stated in the previous
report. But, in the former case, the initial yaw is a
minimum; furthermore, the successive minima decrease numer-
ically, instead of increasing as before. With the higher
air speed, the value of the initial yaw is 13.145°; the
theoretical initial maximum yaw is 14.79°.

   c.   If the orientation of the yaw in the bore is 270°,
the motion is similar to what it is at 300 ft/sec. The
initial yaw, resulting from the higher speed, is 12.845°;
the theoretical initial maximum yaw is 23.47°.

4.   DEVIATIONS: Figures 1 and 2 show the calculated*
deflection and fall, in mils, for the conditions assumed
in paragraph 2. The values for a speed of 300 ft/sec may be
obtained from figures 15 and 16 of the previous report.
The following table shows the results at ranges of 100 yd
(91 m) and 500 yd (457 m).

* M. E. Harrington assisted in the calculations.

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Range	Air Speed	Orientation	Deflection	Fall
yards	ft/sec	deg.	mils	mils
100	600	270	19.9	6.9
		90	14.2	5.7
			5.7	1.2
100	300	270	5.4	3.8
		90	4.4	2.9
			1.0	0.9
500	600	270	85.9	11.8
		90	67.7	10.1
			18.2	1.7
500	300	270.	28.7	8.3
		90	24.1	6.8
			4.6	1.5

5.   DISCUSSION: For comparative purposes, the deviations computed in the classic manner, without yaw, are also shown by the upper curves in figures 1 and 2. It is notable that the effects of windage yaw on the horizontal deflection are greater than on the vertical deviation, whether we consider the maximum dispersion due to initial conditions or the variations from the classic values. Evidently, the increased resistance due to yaw, with the consequent increase in time of flight, is the preponderating cause of the increase in deviation, except at very short ranges. Near the beginning of the trajectory, the so-called cross wind force causes most of the variation: this is apparent from the windage jump, which is almost vertically downward (this is explained in the previous report). For most ranges, therefore, it is more important to determine the drag-yaw coefficient and the damping factors than the cross wind force.

6.   CONCLUSION: The maximum dispersion of 18 mils at 500 yards is quite large. Actually, however, the dispersion will probably be less than this amount, since the yaw in the bore of a caliber 0.30 gun is usually less than 0.15°, and since uniformity in loading conditions tends to group the muzzle orientations within a range of less than 180°. Furthermore, unless fire control mechanism
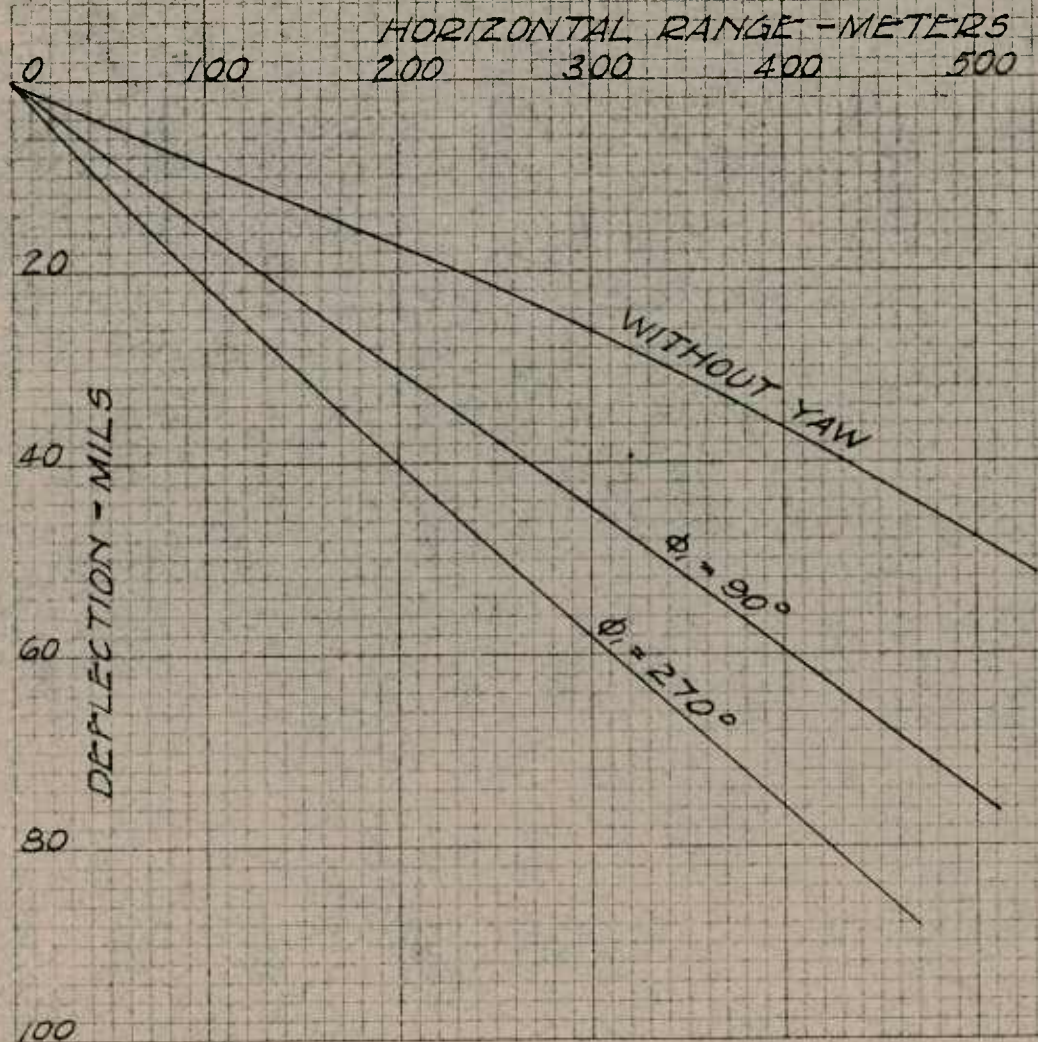
is considerably improved, firing will not be accurate beyond 100 yards, when the air speed is 400 mi/hr. At this range, the total dispersion due to variations of the yaw at the muzzle is less than 6 mils. This should cause no difficulty in hitting.
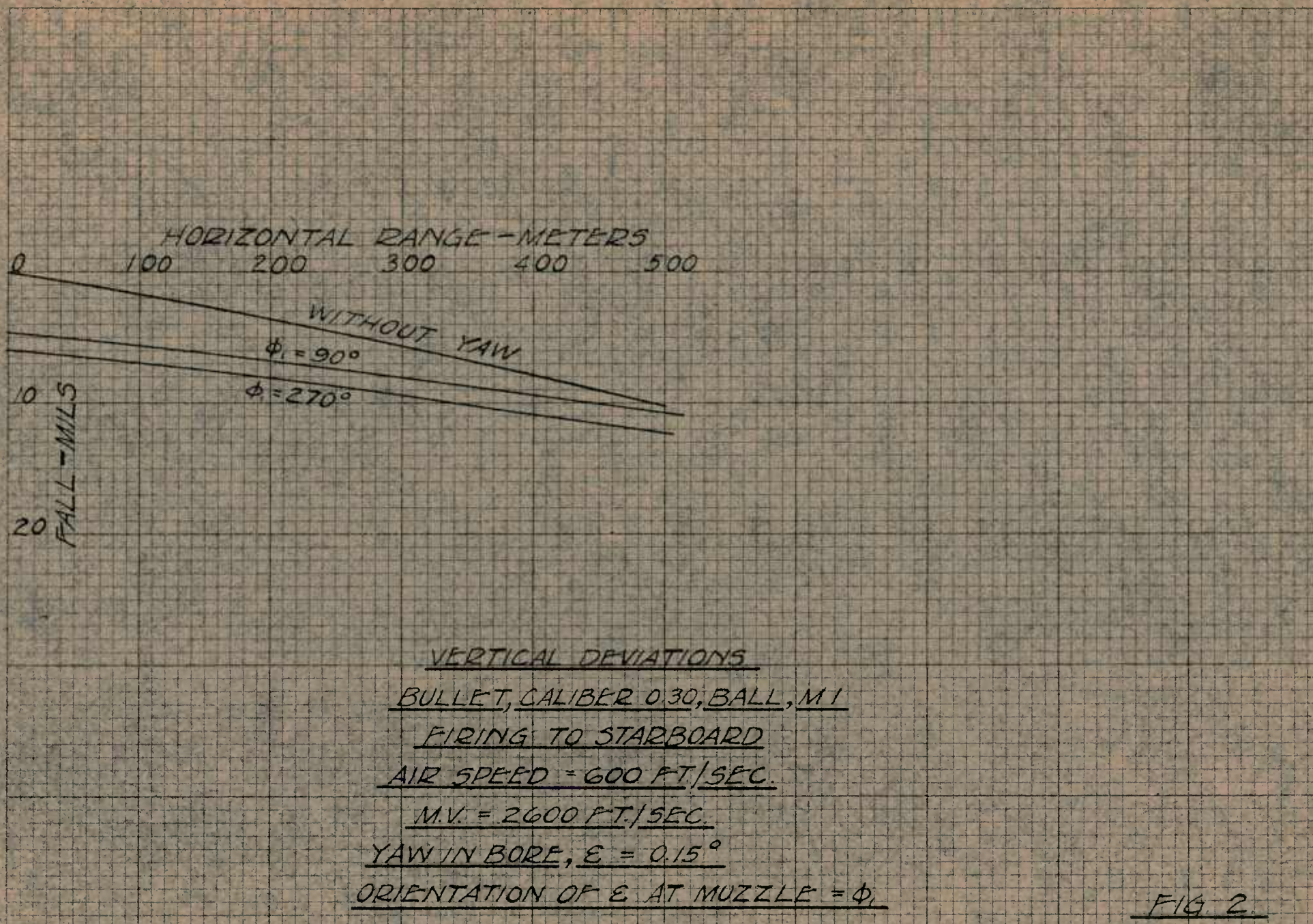
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HORIZONTAL RANGE — METERS

0   100   200   300   400   500

0

20

40

60

80

100

DEFLECTION — MILS

WITHOUT YAW

$\phi_1 = 90°$

$\phi_1 = 270°$

HORIZONTAL DEVIATIONS
BULLET, CALIBER 0.30, BALL, M1
FIRING TO STARBOARD
AIR SPEED 600 FT/SEC.
M.V. = 2600 FT/SEC
YAW IN BORE, ε = 0.15°
ORIENTATION OF ε AT MUZZLE = ϕ_1

FIG. 1.

HORIZONTAL RANGE — METERS

0   100   200   300   400   500

WITHOUT YAW

$\Phi_1 = 90°$

$\Phi_1 = 270°$

FALL — MILS

0

10

20

VERTICAL DEVIATIONS

BULLET, CALIBER 0.30, BALL, M1

FIRING TO STARBOARD

AIR SPEED = 600 FT./SEC.

M.V. = 2600 FT./SEC.

YAW IN BORE, $\varepsilon = 0.15°$

ORIENTATION OF ε AT MUZZLE = Φ_1

FIG. 2

ABSTRACT:

The motion of bullets fired from a machine gun mounted on an airplane in a direction perpendicular to the line of flight of the airplane was studied. Maximum dispersions caused by variations in the magnitude and orientation of the yaw in the bore were determined. At a speed of 400 miles per hour large dispersions occurred at a range of 500 yards but not at 100 yards. For comparative purposes the computed deviations without yaw were shown graphically. It was notable that the effects of windage yaw on the horizontal deflection are greater than on the vertical deviation.